

Review of the Genus *Placiphorella* Dall, 1879,  
*ex* Carpenter MS (Polyplacophora: Mopaliidae)  
with Descriptions of Two New Species

by

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*Abstract.* The genus *Placiphorella* Dall, 1879, *ex* Carpenter MS is reviewed. Nine species are recognized: *P. velata* Dall, 1879, *ex* Carpenter MS; *P. rufa* Berry, 1917; *P. blainvillei* (Broderip, 1832); *P. mirabilis* sp. nov.; *P. hanselmani* sp. nov.; in the eastern Pacific, *P. borealis* (Pilsbry, 1892); *P. stimpsoni* (Gould, 1859) and *P. boreali-japonica* Saito & Okutani (1989) in the western Pacific; and *P. atlantica* (Verrill & Smith, 1882) a bathyal-abyssal, cosmopolitan species. Each species is described and illustrated, and its habitat and distribution are discussed. The conspecificity of *P. atlantica* and *P. pacifica* Berry, 1919, is demonstrated, and its broad geographic distribution is discussed.

INTRODUCTION

The genus *Placiphorella* Dall, 1879, *ex* Carpenter MS is unusual among chitons in having a broad anterior expansion of the girdle, a relatively small foot and a modified pallial fold. In these features it is similar to genera in two other families, namely *Craspedochiton* Shuttleworth, 1853 (Cryptoplacidae), and *Loricella* Pilsbry, 1893 (Schizochitonidae), as noted by Saito & Okutani (1992). These modifications reach their greatest development in *Placiphorella* in the form of precephalic tentacles, which facilitate the active trapping and manipulation of live prey (McLean, 1962). The underside of the "head flap" in living animals of *P. velata* and *P. borealis* is brightly colored, with blotches of reddish or purple, and may act as a lure for prey. In addition to the trapping method of feeding, *Placiphorella* species also graze on encrusting sponges, bryozoans, hydroids, compound ascidians, and (rarely) certain types of algae. The setae of most species of *Placiphorella* are host to several species of sessile foraminifera, some of which may be host-specific.

The last review of the genus as a whole was that of Pilsbry (1893). At that time, five species were considered to be members: *Placiphorella velata* Dall, 1879, *ex* Carpenter MS; *Chiton stimpsoni* Gould, 1859; *Placiphorella*

*borealis* Pilsbry, 1893; *Chiton blainvillii* Broderip, 1832; and *Chiton petasus* Reeve, 1847. *Placophora* (*Euplacophora*) *atlantica* Verrill & Smith, 1882, was considered by Pilsbry to be a member of the genus *Plaxiphora* Gray, 1847 (subgenus *Placophoropsis* Pilsbry, 1893).

Thiele (1909) listed *Chiton blainvillii*, *C. stimpsoni*, and *C. petasus* as members of *Placiphorella*, *sensu stricto*, and *Placophora atlantica* as a member of the subgenus *Placophoropsis*, but made no mention of *Placiphorella velata* (type species of the genus), or *P. borealis*. Recent authors have followed Thiele's revision, except with regard to *Chiton petasus*, which is now known to be in the genus *Craspedochiton* Shuttleworth, 1853.

The present paper recognizes nine species, five in the eastern Pacific Ocean, three in the western Pacific Ocean, and one cosmopolitan. This review focuses primarily on the eastern Pacific species. The western Pacific species, which have been recently revised by Saito & Okutani (1989), are discussed briefly (except for *Placiphorella borealis* Pilsbry, 1892, which is included in the present review because of its presence in the Aleutian Islands), and the reader is referred to the aforementioned paper. Two new species, which previously were confused with *P. velata* and *P. stimpsoni*, are described. The morphological characters of each species are described and illustrated, and nomenclatural confusion is clarified by critical examination of type material, as well as several hundred additional specimens from throughout the geographical range of each species.

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## MATERIALS AND METHODS

Live animals were collected by hand intertidally by SCUBA in shallow water (1–30 m) and by dredging and trawling in deeper water (30–300+ m). Whole animals were preserved dry with glycerin using a slightly modified version of the method of Hanselman (1970). Animals were killed by submersion in hot water (>38°C) for several minutes, fixed in 50% isopropanol (or, when available, ethanol) for 5–6 days, then transferred to the alcohol/glycerin solution for final preservation. This method was used because it reduces the amount of storage space required. A few specimens of each species were disarticulated for study of the interior characters of the valves.

Radulae were extracted after dissolution of tissue in 10% KOH at room temperature. The radular ribbons were washed in distilled water, dehydrated in an acetone series, air-dried, mounted on stubs with a thin smear of colloidal silver paint, and sputter-coated with gold.

Setae were removed from preserved specimens and prepared in the same manner as the radulae. Setae and radula specimens were examined at 5 or 10 kv, with an Hitachi S-2100 scanning electron microscope at the Biology Department of Southern Oregon State College (Ashland, Oregon).

Abbreviations of institutions used in the text are as follows. ANSP, Academy of Natural Sciences, Philadelphia; BMNH, the Natural History Museum, London; CAS, California Academy of Sciences, San Francisco; LACM, Los Angeles County Museum of Natural History; LACMIP, Invertebrate Paleontology collection of LACM; NMFAB, National Marine Fisheries Service, Auke Bay Fisheries Laboratory, Auke Bay, Alaska; RBCM, Royal British Columbia Museum, Victoria; RMNH, National Museum of Natural History, Leiden; RNC, the private collection of the author; SBMNH, Santa Barbara Museum of Natural History; UAF, University of Alaska Museum, Fairbanks; UCD, University of California, Davis, Geerat Vermeij Collection; USNM, United States National Museum of Natural History, Washington, D.C.; ZIAS, Zoological Institute, Academy of Sciences, St. Petersburg.

## SYSTEMATICS

Polyplacophora Blainville, 1816

Neoloricata Bergenhayn, 1955

MOPALIIDAE Pilsbry, 1893

*Placiphorella* Dall, 1879, ex Carpenter MS

**Type species:** *Placiphorella velata* Dall, 1879, ex Carpenter MS by original designation.

Synonyms: *Placophoropsis* Pilsbry, 1893 [type by subsequent designation *P. atlantica* Verrill & Smith, 1882]; *Langfordiella* Dall, 1925 [type by original designation *L. japonica* Dall, 1925 (= *Chiton stimpsoni* Gould, 1859) (Saito & Okutani, 1989)].

Small to medium size chitons, round to oval in outline. Valves very wide and short; lateral areas usually well defined. Articulamentum white to blue-green; head valve with (normally) eight slits; intermediate valves with one slit per side; tail valve with one slit on each side (sometimes obsolete), separated by a caudal sinus. Girdle broadly extended anteriorly and bearing scaled bristles (resembling snakeskin). Pallial fold modified anteriorly into numerous fingerlike extensions (precephalic tentacles). Radula with tricuspid major lateral teeth.

*Placiphorella velata* Dall, 1879, ex Carpenter MS

(Figures 1–3, 26, 27)

*Placiphorella velata* Carpenter MS, Dall, 1879:298, pl. 2, fig. 36; Pilsbry, 1893:306, pl. 66, figs. 6–12; Pilsbry, 1898:288; Berry, 1907:52; Berry, 1917a:241; Chace & Chace, 1919:43; Dall, 1921:196; Berry, 1922:453, pl. 3, figs. 13–15; Oldroyd, 1927:315 [917]; Johnson & Snook, 1927:566, fig. 667; Chace & Chace, 1933:123; Leloup, 1942:11, fig. 4; Smith & Gordon, 1948:206; Berry, 1951:214; Smith, 1960:62, fig. 40; McLean, 1962:23, figs. 1–2; Burghardt & Burghardt, 1969:34, pl. 4, fig. 70; Thorpe (in Keen), 1971:882 (in part), fig. 50; Abbott, 1974:403, fig. 4737; Burghardt, 1979:10; Kaas & Van Belle, 1980:137; Putman, 1980:32; Clark, 1982:152; Clark, 1983a:11; Kozloff, 1987:189, fig. 11.13; Baxter, 1987:106; Saito & Okutani, 1989:209; Skoglund, 1989:86 (in part); Clark, 1991:96; Anderson, 1992:205.

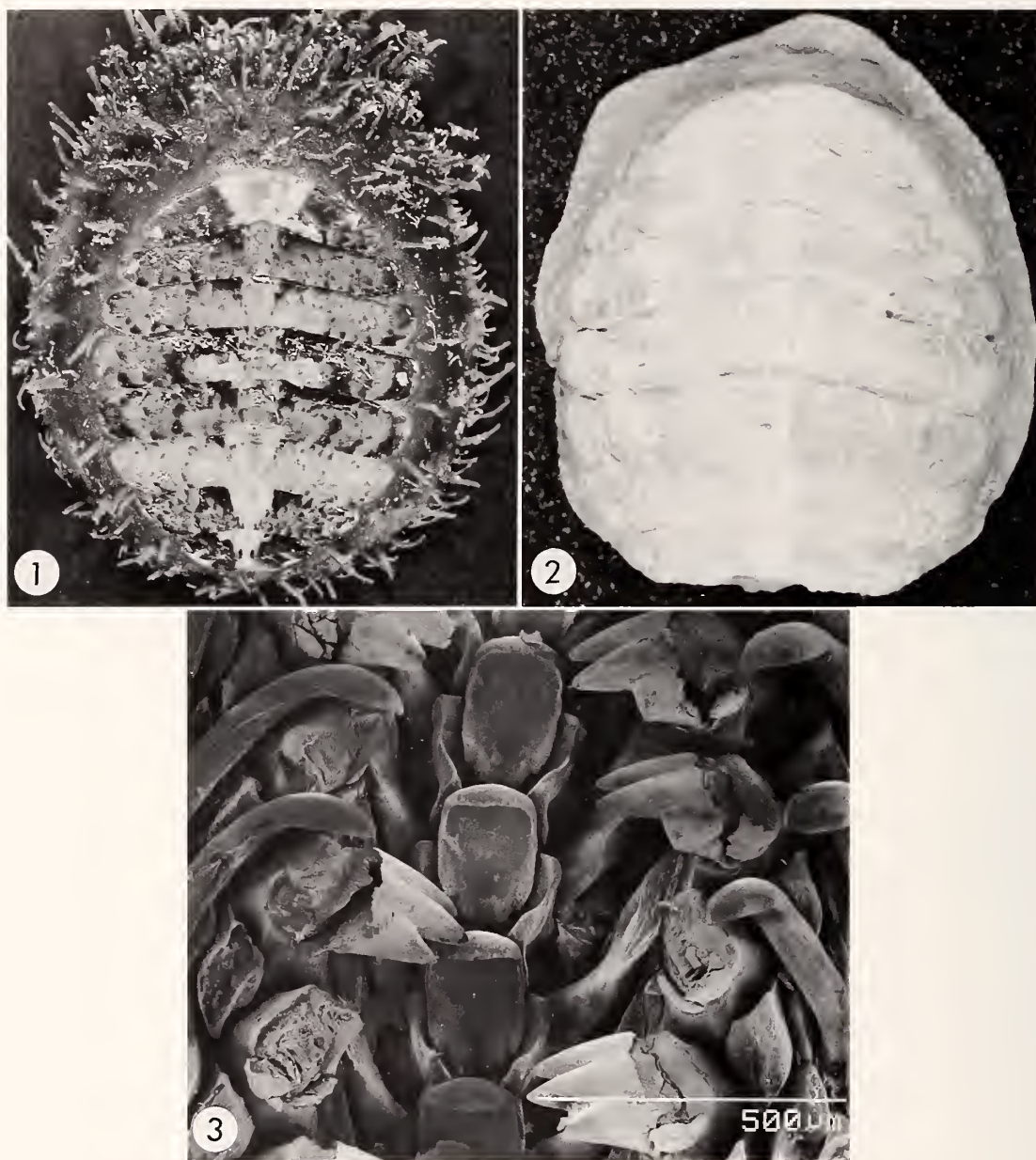
*Placiphorella stimpsoni* (Gould) Dall, 1921:197 (in part); Oldroyd, 1927:316 [918]; Burghardt & Burghardt, 1969:35 (in part); Putman, 1980:132 (in part); Baxter, 1987:106. *Non Chiton stimpsoni* Gould, 1859.

*Placiphorella* sp. Kohl, 1974:214.

**Diagnosis:** Chitons of medium size (to 6.0 cm), round to oval in outline; valves streaked with brown, buff, pink, blue, and olive. Girdle covered with setae of several sizes, clothed with mammillated scales 190–200  $\mu\text{m}$  in length and 40–45  $\mu\text{m}$  in width. Rachidian tooth of radula oblong in outline, sides nearly straight, and distally arched; 225–230  $\mu\text{m}$  in length and 155–160  $\mu\text{m}$  in width.

**Description:** Body (Figure 1), broadly oval in outline, valves depressed, subcarinate, side slopes nearly straight to convex, surface of valves microgranular; color brown to chestnut, streaked with buff, pink, blue, and olive. Girdle widely extended anteriorly, covered with rather short, stiff setae, uniform light brown, brown or olive in color. Lectotype (Figure 2) 44.5 mm  $\times$  38.0 mm  $\times$  13.0 mm (slightly contracted). Largest specimen examined (RNC 367d) 61.0 mm  $\times$  44.5 mm  $\times$  10.0 mm (Neah Bay, Clallan County, Washington).

**Valves:** Head valve crescent-shaped, anterior slope concave in young, strongly convex in very old specimens, with small, rounded notch at apex; tegmental surface sculptureless except for concentric growth lines; interior smooth, strongly thickened anteriorly; insertion teeth short and thick; slits generally eight but occasionally more due to splitting; slit rays faint in young, inconspicuous adults.



## Explanation of Figures 1 to 3

*Placiphorella velata* Dall, 1879, ex Carpenter MS.

Figure 1. Whole animal, RNC 376. Brookings, Curry County, Oregon. 33.0 mm × 28.0 mm.

Figure 2. Lectotype, ANSP 35756. Todos Santos Bay, Baja California, Mexico. 44.5 mm × 38.0 mm.

Figure 3. Radula, RNC 367. Neah Bay, Clallam County, Washington, 1 m.

Intermediate valves very wide and short, oblong in outline, unbeaked, marked by concentric growth lines; lateral areas well defined, raised and slightly depressed medially; central areas often with a false beak (a narrow forward projection at the dorsal ridge); interior smooth with transverse callus extending from center to near the slits; slit rays inconspicuous; sutural laminae very wide, thick, with

a nearly straight and sharp anterior edge, separated by a relatively narrow jugal sinus; insertion plates short and thick, but extending well beyond the narrow eaves.

Tail valve small, depressed; mucro posterior, recurved and elevated; posterior margin indented; sutural laminae broad, truncated anteriorly, separated by a narrow sinus; insertion teeth very short and thick; interior with thick,

transverse callus, extending (and narrowing) from center to near tips of sutural laminae; one (rarely two or more) slits per side, separated by a shallow caudal sinus.

**Girdle:** Wide, broadly extended anteriorly and covered with large, scaled setae (Figure 26). Scales (Figure 27) rather elongate, about 190–200  $\mu\text{m}$  in length and 40–45  $\mu\text{m}$  in width, proximally pointed, distally rounded, with a small spicule at the tip; and scattered, very minute, pointed scales about 25  $\mu\text{m}$  in length. Margin of girdle with slender, pointed spicules about 145  $\mu\text{m}$  in length.

Pallial fold strongly developed, incised posteriorly, modified anteriorly into 16–22 fingerlike projections (precephalic tentacles). Gills nearly holobranchial, extending from anterior margin of valve ii to posterior margin of valve vi, about 18–22 per side in specimens over 20 mm in length.

**Radula** (Figure 3): With about 42 rows of mature teeth (in specimen 27 mm in length [RNC 367a]); rachidian tooth oblong in outline, sides nearly straight, top slightly arched; basal portion abruptly constricted and somewhat thickened, about 225–230  $\mu\text{m}$  in length and 155–160  $\mu\text{m}$  in width; minor lateral teeth roughly triangular, with a centro-lateral spur, thickened from the base to the antero-lateral corner, about 230  $\mu\text{m}$  in length; spatulate uncinial teeth relatively thick and narrow, about 395  $\mu\text{m}$  in length.

**Type locality:** Todos Santos Bay, Baja California, Mexico (31°53'N, 116°32'W).

**Type material:** ANSP 35756: **Lectotype** (largest specimen) and two **paralectotypes** (herein designated) [*leg.* Joseph Jeans (*ex* H. Hemphill)].

**Additional material:** ALASKA: 1 specimen, LACM 141156; 1, RNC 220, English Bay, Hichinbrook Island, Prince William Sound; 3, RNC 236, Saint Lazaria Island, Sitka Sound; 1, RNC 505, Dall Island. BRITISH COLUMBIA, CANADA: 3, RNC 335, Sooke, SW Vancouver Island; 1, RBCM 980-331-6, Cape Perkins, Quatsino Sound, Vancouver Island, 11 m. WASHINGTON: 37, RNC 367, Neah Bay, Clallan County. OREGON: 1, RNC 27, Sunset Bay, Coos County; 1, RNC 961, Island Rock, SW of Port Orford, Curry County, 19 m; 12, RNC 376, Brookings, Curry County. CALIFORNIA: 3, CAS 017676, Patricks Point, Humboldt County, 0–1 m; 4, CAS 017666, Salmon Creek (mouth), Mendocino County, 0–1 m; 3, RNC 1121, Monterey Bay, 5–6 m; 1, CAS 017674, Deadman Island, San Pedro Bay, Los Angeles County. MEXICO: 2, CAS 075733, Bahía Puerto Escondido, Baja California Norte, 6 m; 1, LACM 51-16.1, 16 km W of Punta Malarrimo, Baja California Sur; 1, LACM 71-14.41, E side of Punta Entrada, at Sail Rock, N entrance to Bahía Magdalena, Baja California Sur; 1, LACM 71-14.41, E side of Punta Entrada, at Sail Rock, N entrance to Bahía Magdalena, Baja California Sur, 3–15 m.

**Distribution:** *Placiphorella velata* ranges from south-central Alaska to central Baja California, but it is very rare north of Vancouver Island. The northernmost record is English Bay, Hichinbrook Island, Prince William Sound,

Alaska (60°17'05"N, 146°40'07"W) (LACM 141156). The southernmost record is E side of Punta Entrada, at Sail Rock, N entrance to Bahía Magdalena, Baja California Sur, Mexico (24°32.4'N, 112°04'W) (LACM 71-14.41).

**Habitat:** *Placiphorella velata* is found from 0–20 m, under ledges and in crevices, on the tops, sides, and bottoms of cobbles and boulders, and in sea urchin (*Strongylocentrotus purpuratus*) excavations in bedrock, mostly in areas of light to moderate wave action or tidal flow.

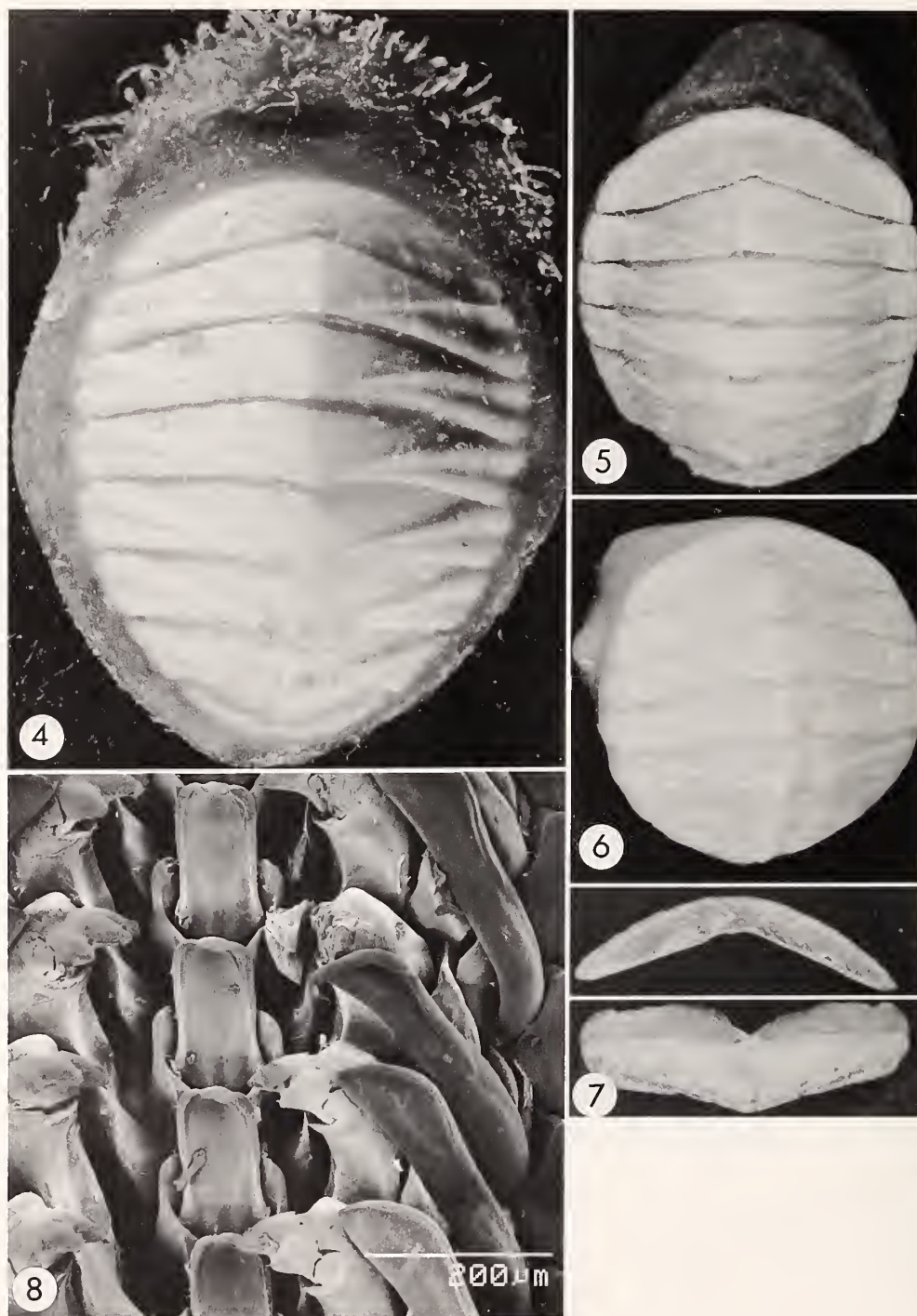
**Fossil record:** An intermediate valve of *P. velata* has been found in the Pleistocene deposits at First Army terrace, Army Camp Beach, San Nicolas Island, California (LAC-MIP loc. 11004), and Hilltop Quarry (upper sand facies), Los Angeles County, California (SBMNH 35631).

**Remarks:** *Placiphorella velata* has been confused with *P. stimpsoni* (Gould, 1859), *P. hanselmani*, and *P. mirabilis*. Recently however, *Placiphorella stimpsoni* has been shown to be restricted to the waters of Japan (Saito & Okutani, 1989) and Korea (Dell'Angelo et al., 1990). Comparisons to *P. hanselmani* and *P. mirabilis* are included under those species. The type specimens of this species were originally syntypes, and as yet have not been recatalogued (D. Vardes, personal communication, May 1994).

#### *Placiphorella atlantica* (Verrill & Smith, 1882)

(Figures 4–8, 28, 29)

- Placophora* (*Euplacophora*) *atlantica* Verrill & Smith, 1882: 365; Verrill 1884:206, pl. 30, figs. 1–1b.  
*Chiton coronatus* Fischer MS, Locard, 1898:100, pl. 4, figs. 22–25.  
*Placophoropsis atlantica* (Verrill & Smith), Pilsbry, 1893:313, pl. 65, figs. 73–75, pl. 66, figs. 18–24; Leloup, 1942: 14–15, pl. 1, fig. 4, pl. 2, fig. 1a–d.  
*Plaxiphora atlantica* (Verrill & Smith), Johnson, 1915:10; Dautzenberg, 1927:231; Burghardt, 1979:12.  
*Placiphorella borealis* Pilsbry, Berry, 1917b:13, pl. 8, figs. 3–5, pl. 10; Abbott, 1974:403; fig. 4739; Putman, 1980: 133, figs. 65–67. *Non Placiphorella borealis* Pilsbry, 1893.  
*Placiphorella pacifica* Berry, 1919:6; Dall, 1921:197; Oldroyd, 1927:314 [916]; Smith & Hanna, 1952:389, pl. 20, figs. 6, 10, 11; Bernard, 1967:8; Burghardt & Burghardt, 1969:33; Abbott, 1974:403; Talmadge, 1973:232; Smith, 1975:159, figs. 1–4; Burghardt, 1979:11; Kaas & Van Belle, 1980:94; Putman, 1980:131; Clark, 1982: 152; Clark, 1983a:11; Skoglund, 1989:86; Jones, 1989: 12; Clark, 1991:95.  
*Placiphorella uschakovii* Yakovleva, 1952:76, text fig. 37, pl. 6, figs. 1a–c; Taki, 1962:34; Burghardt, 1979:11; Saito & Okutani, 1989:209.  
*Placiphorella albitestae* Taki, 1954:22, pl. 11–15; Taki, 1962: 34; Burghardt, 1979:11; Kaas & Van Belle, 1980:5; Wu & Okutani, 1985:123, figs. 1–8, pl. 1; Kaas, 1985:314; Saito & Okutani, 1989:209.  
*Placiphorella atlantica* (Verrill & Smith), Smith, 1960:162, fig. 40:5; Abbott, 1974:403, fig. 4741; Kaas, 1979:13; Kaas & Van Belle, 1980:12; Sneli, 1992:143, figs. 1–3.  
*Placiphorella stimpsoni* (Gould), Wu & Okutani, 1985:126, figs. 9–18. *Non Chiton stimpsoni* Gould, 1859.



## Explanation of Figures 4 to 8

*Placiphorella atlantica* (Verrill & Smith, 1882).

Figure 4. Whole animal, RNC 627. Attu Island, Aleutian Islands, Alaska, 408 m. 19.0 mm × 14.5 mm.

Figure 5. Holotype, USNM 106921. Martha's Vinyard, Massachusetts, 1170 m. approx. 19.0 mm in length.

Figure 6. Paratype of *Placiphorella uschakovi* Yakovleva, 1952.

CAS 019464. Sakhalin Island, Sea of Okhotsk, Russia, 500 m. approx. 20.0 mm in length.

Figure 7. Lectotype of *Placiphorella pacifica* Berry, 1919, SBMNH 34394. Kasaan Bay, Prince of Wales Island, Alaska, 179 m. Intermediate valve, 1.0 cm in width.

Figure 8. Radula, RNC 627. Attu Island, Aleutian Islands, Alaska, 408 m.

**Diagnosis:** Chitons of medium size (up to 3.6 cm), broadly oval in outline, valves uniform milky white in color. Girdle sparsely covered with spinose setae, especially at the periphery, often bare, except at the periphery. Rachidian tooth of radula rectangular, about 160  $\mu\text{m}$  in length and 85  $\mu\text{m}$  in width, with a small cusp at the center of the working edge.

**Description:** Body (Figure 4) broadly oval in outline; valves depressed, subcarinate, side slopes straight, surface of tegmentum microgranular, uniform milky white in color. Girdle broadly expanded anteriorly, sparsely covered with spinose setae (often missing except at margin), uniform cream to light brown in color. Lectotype (Figure 5) 19.0 mm  $\times$  15.0 mm  $\times$  5.0 mm. Largest specimen examined (RNC 184b) 36.0 mm  $\times$  25.5 mm  $\times$  6.0 mm (N of Umnak Island, Aleutian Islands, Bering Sea, Alaska).

**Valves:** Head valve crescent-shaped, anterior slope concave, posterior margin not raised; tegmentum with 10–20 radiating grooves; interior smooth, thickened anteriorly; insertion teeth short, rarely extending beyond eaves, relatively thick, anteriorly rugose, with 8–20 slits; slit rays obsolete.

Intermediate valves oblong in outline, very wide and short, widest at valve iv, subcarinate, weakly beaked posteriorly, slightly false-beaked in older specimens; lateral areas raised and cut by a wide sulcus into two low ribs; central areas smooth except for growth lines; interior smooth, with transverse callus running from center to near slits; slit rays obsolete; sutural laminae very large and thick, nearly straight, sharp at anterior edge, separated by a jugal sinus; insertion teeth extending well beyond eaves.

Tail valve small, depressed; mucro posterior and raised; anterior area smooth except for growth lines; posterior area thickened, posterior margin indented; sutural laminae broad, truncated anteriorly, separated by a rather narrow sinus; insertion teeth very short (often obsolete) and thick; interior with thick posterior callus; normally with one slit per side, but range from 0–2, separated by a shallow sinus.

**Girdle:** Narrow posteriorly, becoming broadly extended anteriorly, covered with minute, weakly striated spicules 50–55  $\mu\text{m}$  in length; margin of girdle with short, spinose series of setae up to 0.5 mm in length, and posterior to this series one to two longer series of setae (Figure 28) about 2 mm in length, with tightly packed spicules. Similar setae scattered about surface of "head flap," but usually broken off. Spicules of setae (Figure 29) sharply pointed distally, about 25  $\mu\text{m}$  in length and 3.5  $\mu\text{m}$  in width; margin of girdle fringed with blunt, very weakly striated spicules about 75  $\mu\text{m}$  in length; hyponotum (except for head flap) clothed with minute spicules about 25  $\mu\text{m}$  in length; head flap with minute papillae and sparsely scattered spicules.

Pallial fold well developed, incised posteriorly, modified anteriorly into 7–10 precephalic tentacles. Gills nearly holobranchial, extending from under suture of valves ii and iii to valves vii; about 20–24 plumes per side in specimens over 20 mm in length.

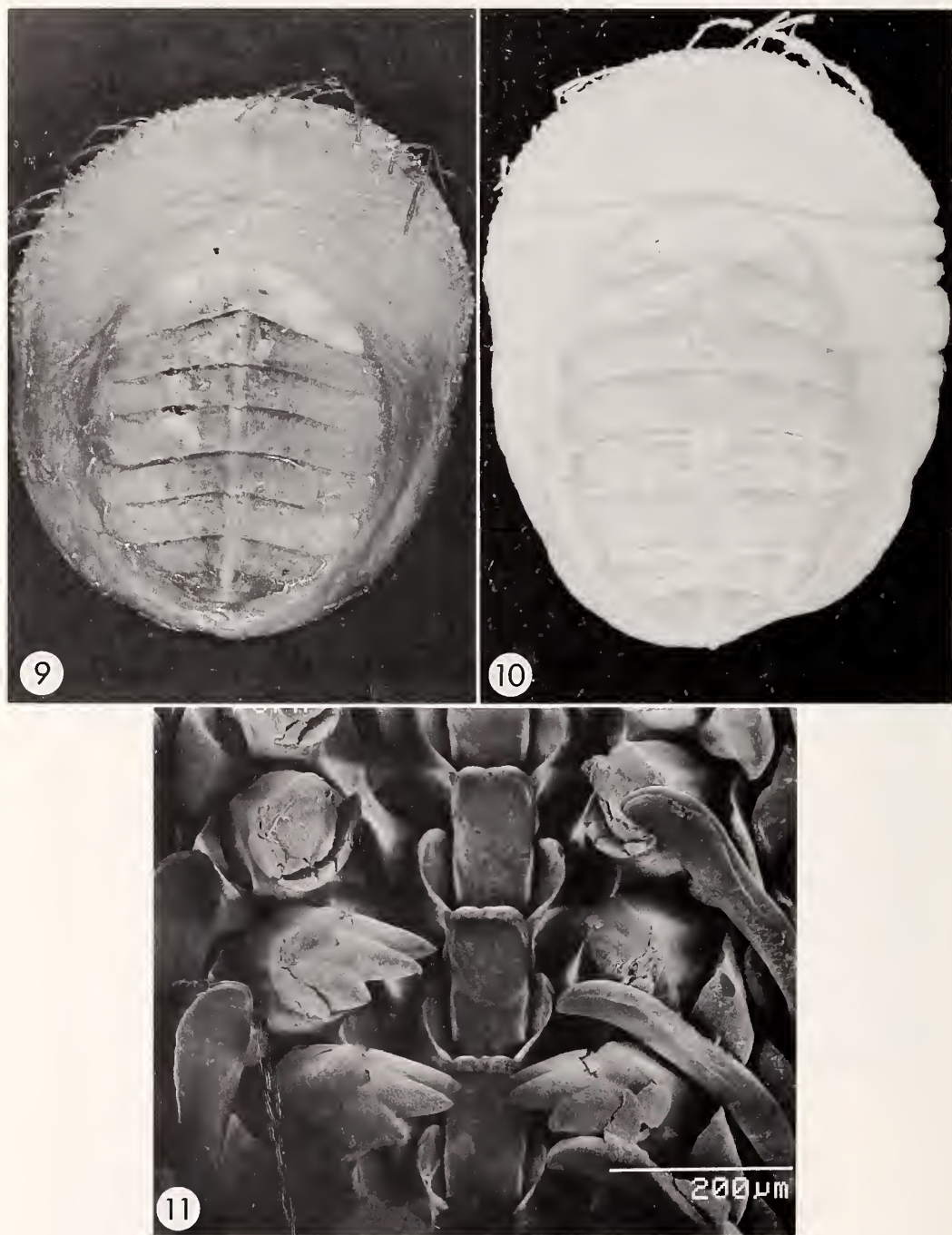
**Radula** (Figure 8): 5 mm in length (in specimen 20 mm long [RNC 184a]) with about 30 rows of mature teeth; rachidian tooth 160  $\mu\text{m}$  in length, working edge about 85  $\mu\text{m}$  in width, spatulate uncinals very large, about 300  $\mu\text{m}$  in length and 60–65  $\mu\text{m}$  in width at distal end; outer edge thickened and rounded distally, inner edge nearly straight, forming a sharp angled corner where they meet.

**Type locality:** Off Nantucket Island, Massachusetts (40°01'N, 68°54'W), 1170 m.

**Type material:** Holotype, USNM 106921; holotype of *P. uschakovi*, ZIAS; paratype of *P. uschakovi*, CAS 019464, N of Cape Elizabeth, Sakhalin Island, Sea of Okhotsk, Russia, 500 m; lectotype of *P. pacifica*, SBMNH 34394, Kasaan Bay, Prince of Wales Island, SE Alaska, 173–179 m.

**Additional material:** RUSSIA: 1, CAS 014381, NE Sea of Okhotsk, 420 m; 2, SBMNH 35135, off Cape Rollin, Simurshir Island, Kurile Islands, 416 m. ALASKA: 9, RNC 184, N of Umnak Island, Aleutian Islands, 228–274 m; 2, RNC 627, Attu Island, Aleutian Islands, 408 m; 1, RNC 689, Gulf of Alaska, W of Prince of Wales Island, 461 m; 1, Cowan Collection RBCM, near Prince of Wales Island, 205 m. BRITISH COLUMBIA, CANADA: 1, LACM 25177, off Queen Charlotte Islands, 1280 m; 1, Cowan Collection, RBCM, WNW of Triangle Island, 860–878 m; 1, Cowan Collection RBCM, off N end of Vancouver Island, 155 m. OREGON: 3, Cowan Collection RBCM, off Lincoln County; 1, CAS 014379, off Coos County, 1000 m. CALIFORNIA: 1, CAS 014375, off Cordell Bank, Marin County, 365–730 m; 2, CAS type series 561, 562, Pioneer Seamount, off San Mateo County, 914–1189 m; 1, LACM 10543, Monterey Submarine Canyon, Monterey Bay, 500 m; 1, CAS 014301, NW of Point Pinos, Monterey County, 366 m. MEXICO: USNM 206614 off Guaymas, Sonora (depth not stated). CHILE: 1, CAS uncatalogued, off Soutar, 420–450 m. SOUTH PACIFIC OCEAN: 1, LACM 34412, SW of Auckland Islands, New Zealand (51°07'S, 162°02'E), 1647–1665 m; 1, LACM 118723, N of Macquarie Island, Australia (54°32'S, 159°02'E), 494–714 m; 2, LACM uncatalogued, South Tasmanian Rise (42°21'S, 147°51'E), 910–915 m; 2, RMNH K5066, Makassar Strait, Indonesia (00°02'S, 119°50'E), 411–445 m. FRANCE: 1, RMNH K4753, Bay of Biscay (47°40.9'N, 08°5.7'W), 1174 m.

**Distribution:** Cosmopolitan, bathyal-abyssal. *Placiphorella atlantica* is one of only two species of chitons (the other is *Leptochiton alveolus* [Lovén, 1846, ex Sars MS]) known to be distributed throughout the world's oceans, having been collected off the Atlantic coast of North America from near Maine (Pilsbry, 1893) to off Florida (B. Sirenko, personal communication, 1992); off Europe and Africa between latitudes 25°N and 62°N (P. Kaas, personal communication, 1992); off the Pacific coast of North America from the Bering Sea to the Gulf of California; off South America near Chile; off Asia from the Sea of Okhotsk to



Explanation of Figures 9 to 11

*Placiphorella rufa* Berry, 1917.

Figure 9. Whole animal, RNC 413. Mountain Point, 8 km S of Ketchikan, Revillagigedo Island, Alaska, 25-30 m. 35.0 mm × 30.0 mm.

the Makassar Strait, Indonesia; near Australia, Tasmania, and New Zealand; and in Antarctic seas.

**Habitat:** Found at depths of 155 to 1665 m on rocks and boulders, or in the case of very small juveniles (<9 mm)

Figure 10. Holotype. SBMNH 34373. Forrester Island, Alaska, 46 m. 32.0 mm × 26.0 mm.

Figure 11. Radula (RNC 413).

in the Aleutian Islands, on the giant bathyal-abyssal barnacle *Balanus evermani*, sometimes near an unidentified, thin, light tan to yellow encrusting sponge.

**Remarks:** Comparison of the holotype of *Placiphorella at-*

*lantica* (Figure 5) with several specimens of *P. pacifica* from throughout the Pacific demonstrated their conspecificity. Authors since Pilsbry (1893) have placed this species in the subgenus *Placophoropsis* Pilsbry, 1893, based on the lack of slits in the tail valve of the holotype. However, this is an aberrant character, as the number of slits in the tail valve of most species of *Placiphorella* varies with age. Berry (1919) did not designate a type in his original description, and the specimen has subsequently been designated as a lectotype by Scott et al. (1990:8).

*Placiphorella rufa* Berry, 1917

(Figures 9–11, 30, 31)

*Placiphorella rufa* Berry, 1917a:232, figs. 3–4; Dall, 1921:127; Oldroyd, 1927:316 [918]; Burghardt & Burghardt, 1969:34, pl. 4, fig. 69; Abbott, 1974:403; Burghardt, 1979:11; Putman, 1980:134, fig. 68; Kaas & Van Belle, 1980:114; Clark, 1982:152; Clark, 1983a:11; Baxter, 1987:106; Clark, 1991:95; Anderson, 1992:205 (fig. only).

*Placiphorella borealis* Pilsbry, Vermeij et al., 1990:349. *Non P. borealis* Pilsbry, 1893.

**Diagnosis:** Chitons of medium size (to 5.0 cm), broadly oval; valves uniform reddish in color. Girdle nude except at periphery, which bears two series of long, slender setae. Rachidian tooth of radula rectangular, about 160  $\mu$ m in length and 90–95  $\mu$ m in width, bearing very slight indentation at center of distal end.

**Description:** Body (Figure 9) broadly oval in outline; valves depressed, subcarinate, side slopes nearly straight to convex; tegmentum microgranular, uniform reddish in color (central portion of head valve paler). Girdle broadly extended anteriorly, uniformly cream or mottled cream and green in color, nude except at margin which bears four series of setae, the inner two series fairly long (up to 5.0 mm), slender, reddish-brown in color. Holotype (Figure 10) 32.8 mm  $\times$  26.0 mm  $\times$  6.0 mm. Largest specimen examined (RNC 1126) 55.0 mm  $\times$  46.0 mm  $\times$  8.5 mm (Ketchikan, Revillagigedo Island, Alaska).

**Valves:** Head valve crescent-shaped, anterior slope concave, posterior margin raised, apical notch small; tegmentum with 8–11 faint radial grooves; interior smooth, thickened anteriorly; insertion teeth short, thick, pectinate, with 7–10 (normally eight) slits; slit rays obsolete.

Intermediate valves oblong in outline, very wide and short, widest at valve iv, sub-carinate, slightly beaked posteriorly, false-beaked anteriorly; lateral areas raised, flattened; central areas smooth except for growth lines; interior smooth, with transverse callus running from center to near slits; slit rays obsolete; sutural laminae very large and thick, nearly straight, sharp at anterior edge, separated by a sinus, not usually connected across the jugum; insertion teeth long for genus, extending far beyond narrow eaves; one slit per side.

Tail valve small, roughly rhombic, width including articulation nearly three-fourths the width of valve iv

tegmentum; anterior margin convex, anterior area smooth except for growth lines; mucro at posterior one-third; posterior margin straight or very weakly indented; lateral ribs raised, posterior area slightly swollen; sutural laminae very broad, truncated anteriorly, separated by rather narrow sinus; insertion teeth very short; with one slit per side separated by shallow caudal sinus.

**Girdle:** Nude dorsally except at margin, which bears four series of setae, the outer two series very short (<0.5 mm) and spinose; inner two series (Figure 30) fairly long (up to 9.0 mm), with tightly packed, long, smooth scales tapering to a point proximally, and bluntly rounded distally (Figure 31), about 250  $\mu$ m in length. Hyponotum nude; margin of girdle fringed with minute, pointed spicules, 50–125  $\mu$ m in length.

Pallial fold well developed, incised posteriorly, modified anteriorly into 12–15 tentacles, the longest at center, becoming gradually shorter toward the edges. Gills merobranchial, extending from under valve ii to the suture of valves vi and vii; about 19–22 plumes per side.

**Radula** (Figure 11): 11.0 mm long (in specimen 36 mm long [RNC 903]) with about 40 rows of mature teeth; rachidian tooth rectangular, about 160  $\mu$ m in length, working edge about 90–95  $\mu$ m wide; spatulate uncinial teeth about 375  $\mu$ m in length, flattened, thickened along outside edge, distally rounded, about 40  $\mu$ m in width at base, broadening to about 75  $\mu$ m at distal end.

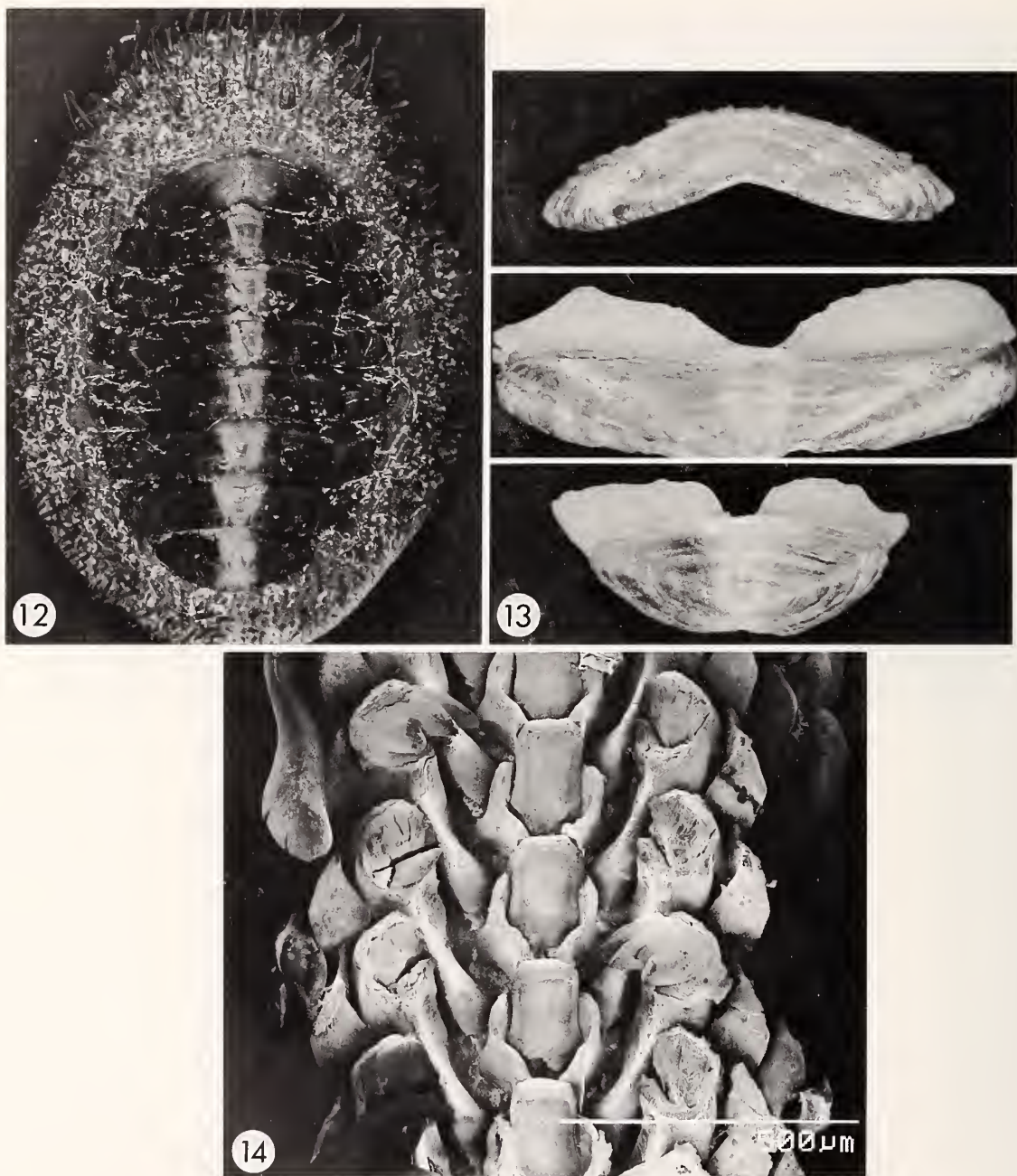
**Type locality:** Forrester Island, SE Alaska (54°50'N, 133°30'W), 27–36 m.

**Type material:** Holotype, SBMNH 34373; Paratypes, 3, SBMNH 34374; 1, SBMNH 34375; 1, SBMNH 34376; 1, CAS 066404.

**Additional material:** ALASKA: 1, UCD uncatalogued, Adak Island, Aleutian Islands, 3–5 m; 1, UAF Collection Spruce Island; 1, RNC 328, Deep Bay, Hawkins Island, 30–35 m; 1, CAS 014377, Prince William Sound; 1, RNC 421, Hesketh Island, Kachemak Bay, 0–1 m; 1, RNC 24, Kachemak Bay, 0–1 m; 1, CAS 014372, Auke Bay, 18 m; 2, CAS 014410, Gambier Bay, Admiralty Island, 18 m; 1, NMFAB AB82-30, Burnett Island, 3–15 m; 2, NMFAB AB82-35, Pybus Bay, Elliot Island, 24 m; 2, RNC 127, Sitka, Barenof Island, 1 m; 13, RNC 1133, Eastern Sukoi Island, 10–15 m; 29, RNC 1126, RNC 903, near Ketchikan, Revillagigedo Island, 3–30 m; 7, RNC 906, Petersburg, Mitkof Island, 1–2 m; 1, RNC 658, Metlakatla, Annette Island, 43 m. BRITISH COLUMBIA, CANADA: 6, RBCM 976-1064-5, Sonora Island; 1, RBCM 976-1046-2, Edward King Island, Barkley Sound. OREGON: 1, LACM 19336; 1, RNC 962, Island Rock, Curry County, 30 m. Seventeen additional lots examined.

**Distribution:** Central Aleutian Islands to southern Oregon. Westernmost record Lucky Point, SW shore Kuluk Bay, Adak Islands, Aleutian Islands, Alaska (51°51'20"N, 176°35'W) 5–7 m (Vermeij Collection, UCD); northernmost record Deep Bay, Hawkins Island, Prince William





Explanation of Figures 12 to 14

*Placiphorella borealis* Pilsbry, 1892.

Figure 12. Whole animal, RNC 947. Bering Island, Commander Islands, Russia, 0-1 m. 34.0 mm × 25.0 mm.

Figure 13. Holotype, USNM 106922. Bering Island, Commander Islands, Russia. Intermediate valve: 25.0 mm in width.

Sound, Alaska (60°40'N, 145°32'W), 30-35 m (RNC 328); southernmost record off Island Rock, Curry County, Oregon (42°40.08'N, 124°28.48'W), 30 m (LACM 19336, RNC 962).

Figure 14. Radula, RNC 192. Atka Island, Aleutian Islands, Alaska, 2 m.

**Habitat:** *Placiphorella rufa* is usually found on the sides and tops of boulders and on vertical rock walls, generally in areas of moderate to heavy current, from the low intertidal to at least 46 m. It is often observed on rock ledges,

situated perpendicular to the current, with its head flap raised 45°–90°.

**Remarks:** *Placiphorella rufa* is a relatively common subtidal species which may be readily distinguished from other members of the genus by the uniform reddish coloration of the valves and by the mostly nude girdle, which bears setae only at the periphery.

The setae of *P. rufa* are host to several species of foraminiferans and two or more unknown species of Hydrozoa, probably of the families Lafoeidae and Campanularidae.

The girdle of *P. rufa* is often mottled with green, particularly in older specimens, probably due to the presence of symbiotic algae. This warrants further investigation.

*Placiphorella borealis* Pilsbry, 1893

(Figures 12–14, 32, 33)

*Placiphorella stimpsoni* (Gould) Dall, 1886:210 (in part). *Non Chiton stimpsoni* Gould, 1859.

*Placiphorella borealis* Pilsbry, 1893:309, pl. 66, figs. 14–17; Dall, 1921:196; Oldroyd, 1927:314; Smith, 1947:19; Yakovleva, 1952:75, figs. 3a–c; Taki, 1962:34; Sirenko, 1973:1569; Sirenko, 1979:200; Burghardt, 1979:11; Kaas & Van Belle, 1980:18; Clark, 1982:152; Clark, 1983a:11; Sirenko & Scarlato, 1983:5; Sirenko, 1985:357; Saito & Okutani, 1989:209, figs. 1–10, 47–48; Clark, 1991:95.

*Placiphorella* sp. O'Clair, 1977:444.

**Diagnosis:** Chitons of medium size (to 4.0 cm); oval in outline; valves uniform brown to dark brown in color, with pale jugal stipe. Girdle covered with brown setae of several sizes; scales of setae broad, roughly diamond-shaped, striated along distal half, and mammillated at distal end. Rachidian tooth of radula subrectangular, 180  $\mu$ m in length and 120  $\mu$ m in width at working edge; posterior third tapering sharply to about 50  $\mu$ m at the base.

**Description:** Body (Figure 12) oval in outline; valves depressed, subcarinate, side slopes nearly straight; tegmentum microgranular, dark brown with cream to white jugal stripe. Girdle broadly extended anteriorly, densely covered with short brown setae of various sizes. Holotype disarticulated (Figure 13); largest specimen examined (RNC 192b, Atka Island, Alaska) 41.0 mm  $\times$  30.5 mm  $\times$  5.0 mm.

**Valves:** Head valve thick, crescent-shaped, anterior slope concave to nearly straight, posterior margin thick, convex, apical notch small, round; tegmentum with six to 10 very low, faint (often obsolete), radiating ribs, and concentric growth lines; interior smooth, thickened anteriorly; insertion teeth short, thick, slightly pectinate, with seven to 10 (normally eight) slits; slit rays obsolete.

Intermediate valves oblong in outline, very wide and short, widest at valve iv, beaked posteriorly in young specimens (<20 mm), becoming unbeaked in adults, slightly false-beaked anteriorly; lateral areas raised, separated into two ribs by a broad groove; central areas unsculptured

except for growth lines; interior smooth, with transverse callus running from center to near slits; with one slit per side, slit rays weakly grooved in young, obsolete in adults; sutural laminae very large and thick, separated by fairly wide jugal sinus, not connected across jugum; insertion teeth long for genus, extending far beyond narrow eaves, upswept (as are sutural laminae) at sides of slits.

Tail valve large for genus, depressed, nearly oval in outline, more than half the width of valve iv tegmentum; anterior margin convex and elevated, mucro at posterior third, slightly raised; anterior area sculptureless except for growth lines, diagonal rib broad and convex; posterior area strongly sloping; posterior margin weakly indented; interior calloused posteriorly; sutural laminae broad, truncated anteriorly, separated by a sinus; insertion teeth very short and thick, with one slit per side.

**Girdle:** Perinotum densely covered with minute, pointed spicules, about 30–45  $\mu$ m in length, and large (up to 4 mm) brown, scaled bristles (Figure 32) of several sizes and series, the largest at about midpoint of girdle, five to seven in front of anterior valve, one adjacent to each valve suture, and three behind posterior valve; similar series at anterior margin of girdle, from about valve ii forward; other bristles of various sizes, scattered; scales of bristles (Figure 33) about 100–120  $\mu$ m in length; striated on distal half, and bearing short spicule. Hyponotum sparsely covered from suture of valves i and ii to anal cleft with smooth, blunt-tipped spicules about 50–60  $\mu$ m in length; anterior portion of hyponotum with numerous small papillae; margin of girdle fringed with slender, blunt-tipped spicules about 100–150  $\mu$ m in length.

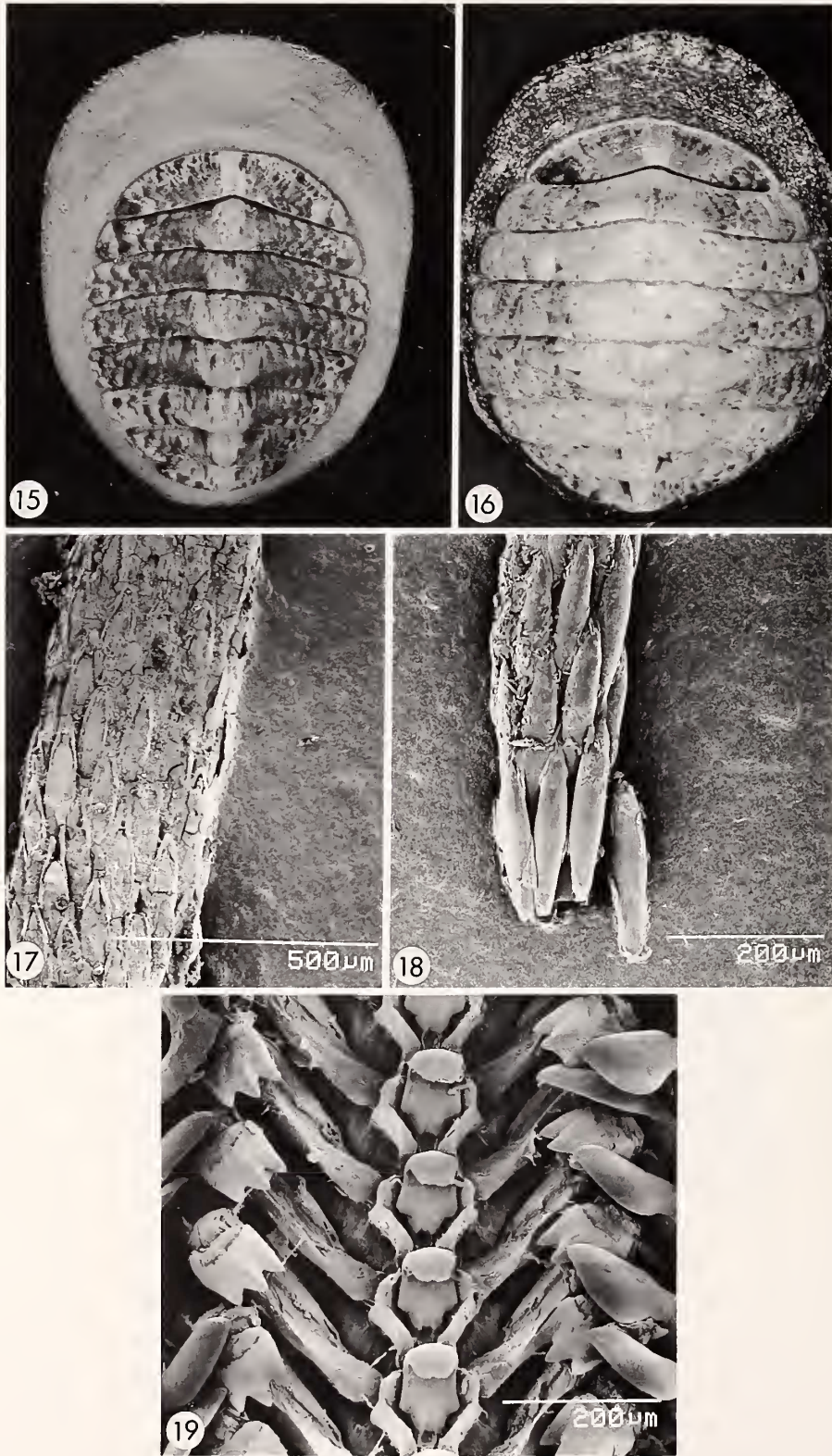
Pallial fold well developed, incised posteriorly, modified anteriorly into 15–24 precephalic tentacles. Gills holobranchial, extending from suture of valves ii and iii to suture of valves vi and vii; 17–21 plumes per side.

**Radula** (Figure 14): Approximately 7.5 mm long (fragmented) in specimen 26.0 mm long (RNC 192b, Atka Island, Alaska), with approximately 33 rows of mature teeth. Rachidian tooth subrectangular, 180  $\mu$ m in length, working edge 120  $\mu$ m in width, posterior third tapering sharply to about 45–50  $\mu$ m in width at base. Spatulate uncinals about 450  $\mu$ m in length, very broad distally (about 120  $\mu$ m), tapering to about 50  $\mu$ m at base.

**Type locality:** Bering Island, Commander Islands, Bering Sea, Russia (55°00'N, 165°15'E).

**Type material:** Holotype, USNM 106922.

**Additional material:** JAPAN: 1, RNC 493, Nosappu, Hokkaido Island. RUSSIA: 1, CAS 014380, Petrova Island, Sea of Japan, 0–1 m; 1, RNC 119, Zelenij Island (Green Island), Kurile Islands, 13 m; 1, RNC 869, Iturup Island, Kurile Islands, 5 m; 1, RNC 733, Paramushir Island, Kurile Islands; 3, CAS 014373, Bering Island, Commander Islands; 2, RNC 947, Bering Islands, Commander Islands; 2, RNC 126, Mendji Island, Commander Islands.



ALASKA: 1, LACM 141155; 3, RNC 192, Atka Island, Aleutian Islands, 1–2 m and 12–18 m.

**Distribution:** *Placiphorella borealis* is distributed throughout the northwestern Pacific island arc, from SE Hokkaido Island, Japan (41°57'N, 143°15'E), to Atka Island, Aleutian Islands, Alaska (52°54'N, 174°18'W).

**Habitat:** *Placiphorella borealis* is found on the bottoms of cobbles and boulders or in crevices in rock walls, from the low intertidal to about 24 m.

**Remarks:** *Placiphorella borealis* was long considered to be a deep-water species, based on Berry (1917b), who described and illustrated specimens of what he interpreted as this species taken at 416 m off Simushir Island, Kurile Islands, Russia, by the *Albatross* expedition in 1906. However re-examination of these specimens has revealed them instead to be *P. atlantica* (Clark, 1991:95).

Sirenko (1973) reported that *P. borealis* broods its young in the pallial grooves. This is the only member of Mopaliidae known to exhibit this behavior. The date of description of *P. borealis* has been cited by some authors as 1892. However, the section of the *Manual of Conchology* that contained the description of *P. borealis* was published in 1893 (see Clench & Turner, 1962).

*Placiphorella blainvillii* (Broderip, 1832)

(Figures 15–19)

*Chiton blainvillii* Broderip, 1832:27; Sowerby, 1833:pl. 38, fig. 6; Reeve, 1847:3, fig. 13.

*Mopalia blainvillii* (Broderip), Gray, 1847:69; Dall, 1879:303.

*Placiphorella blainvillii* (Broderip), Dall, 1886:210; Pilsbry, 1893:310, pl. 66, figs. 26–32; Dall, 1908:357; Dall, 1909:246; Smith, 1960:162, fig. 40:4; Hertlein, 1963:243; Thorpe (in Keen), 1971:882, fig. 49; Smith & Ferreira, 1977:88, fig. 12; Burghardt, 1979:11; Ferreira, 1987:46; Shasky, 1989:75, fig. 4; Skoglund, 1989:86.

**Diagnosis:** Chitons of medium size (to 5 cm), oval to broadly oval in outline; valves white variegated with light brown, olive, and reddish brown, often suffused with pink, especially along the center. Girdle sparsely covered with short setae; scales of setae smooth, cylindrical, and pointed at the distal end. Rachidian tooth of radula angular, pos-

terior third sharply truncated and forming three sharp denticles (very small central, and two large lateral) at base.

**Description:** Body (Figure 15) broadly oval in outline, valves moderately elevated, subcarinate, side slopes straight; tegmentum microgranular, white variegated with light brown and olive or reddish brown, often suffused with pink, especially along the center. Girdle broadly extended anteriorly, sparsely covered with rather fine, short setae; uniform light tan to brown in color. Lectotype (largest specimen examined) 48 mm × 36 mm × 10.5 mm.

**Valves:** Head valve thick, crescent-shaped, anterior slope nearly straight to convex, apical notch small, round; tegmentum sculptureless except for growth lines; interior smooth, thickened anteriorly; insertion teeth short and smooth, not pectinate; with 10 to 13 slits; slit rays obsolete.

Intermediate valves oblong in outline, wide and short, widest at valve iv; beaked posteriorly, slightly false-beaked anteriorly; lateral areas raised and smooth; central areas lacking sculpture except for growth lines; interior smooth, with transverse callus extending from center to near slits; sutural laminae wide and rather short; straight and sharp at anterior edge, connected across jugum; insertion teeth short, smooth, with one slit per side.

Tail valve small, width less than half the width of valve v tegmentum; anterior margin sharply convex; anterior area convex, lacking sculpture except for growth lines; mucro terminal; lateral ribs raised, thick, smooth, sloping sharply to posterior margin of valve. Interior smooth, with posterior callus; sutural laminae long and sharp, not connected across jugum; insertion teeth very short and blunt; one slit per side separated by shallow caudal sinus.

**Girdle:** Perinotum sparsely covered with short, pointed spicules about 150 μm in length, occurring singly or in groups of two or three, and short (1–1.5 mm) yellow-brown setae (Figures 17, 18), in three series at periphery of girdle, one in valve sutures, others sparsely scattered; scales of marginal series smooth, cylindrical, pointed, about 260 μm in length and 45 μm in width; scales of sutural and scattered dorsal series similar to those of marginal series but shorter and proportionally broader, about 190–200 μm in length and 50 μm in width. Hyponotum from posterior edge of head valve to anal cleft carpeted with overlapping, outwardly directed, minute, pointed scales, about 75–80 μm in length and 25–30 μm in width; anterior portion of

Explanation of Figures 15 to 19

*Placiphorella blainvillei* (Broderip, 1832).

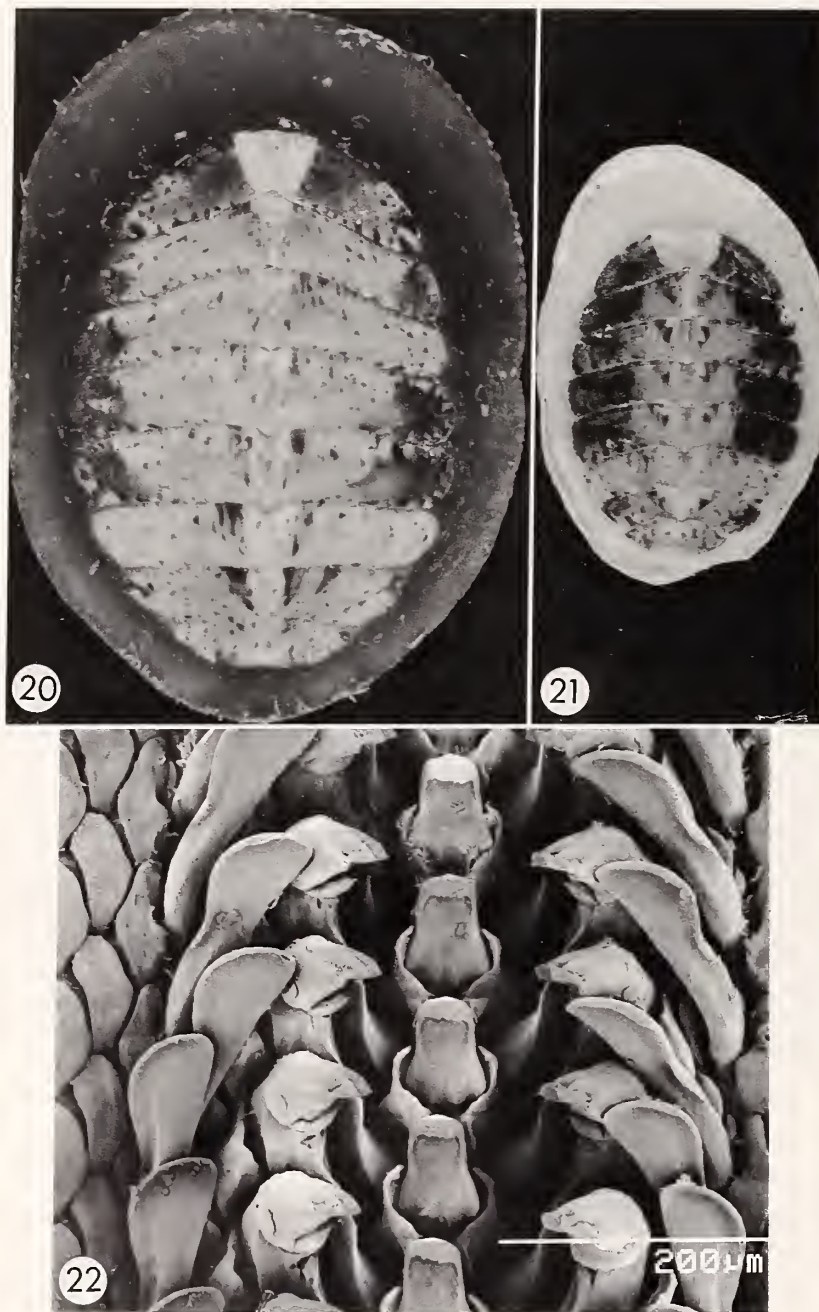
Figure 15. Whole animal, ANSP A13339. Cocos Island, Costa Rica, 80–88 m. 40.0 mm × 31.0 mm.

Figure 16. Paralectotype, BMNH 1967618/3. Lobos de Tierra, Peru, 31 m. 35.5 mm × 28.0 mm.

Figure 17. Dorsal setae, LACM 38–39.4. Cocos Island, Costa Rica, 73–84 m.

Figure 18. Marginal setae, BMNH 1967618/3.

Figure 19. Radula (LACM 38–39.4).



Explanation of Figures 20 to 22

*Placiphorella mirabilis* Clark, sp. nov.

Figure 20. Whole animal, Paratype, RNC 1079. San Nicholas Island, California, 30 m. 24.5 mm × 18.0 mm.

Figure 21. Holotype, LACM 2703. Catalina Island, California, 69 m. 15.25 mm × 10.1 mm.

hyponotum devoid of scales and spicules, bearing only very minute papillae; margin of girdle fringed with sharply pointed spicules, about 180 µm in length.

Pallial fold well developed, incised posteriorly, modified

Figure 22. Radula, Paratype, LACM 2704. Catalina Island, 82-91 m.

anteriorly into 10 to 12 precephalic tentacles. Gills holobranchial, 21-22 plumes per side.

*Radula* (Figure 19): Approximately 8.5 mm along (in specimen approximately 40 mm in length [LACM 38-

39.4]), with about 60 rows of mature teeth; teeth as noted by Thorpe (1971) smaller and more delicate than those of *Placiphorella velata*. Rachidian tooth about 115  $\mu\text{m}$  in length and 65  $\mu\text{m}$  in width, sharply truncated at the proximal third to about 20  $\mu\text{m}$ ; working edge about 55  $\mu\text{m}$  in width. Spatulate uncinial teeth about 300  $\mu\text{m}$  in length, and 25  $\mu\text{m}$  in width at base, exterior convex, interior slightly concave, abruptly dilated at distal half to about 80  $\mu\text{m}$ ; outside margin nearly straight, inside margin sharply rounded laterally, sharply tapering distally to a point where they meet.

**Type locality:** Lobos de Tierra (inner Lobos Island), Peru (6°30'S, 80°50'W).

**Type material:** Six syntypes, one (the largest), BMNH 1967618/1, figured by Pilsbry (1893) here designated as the lectotype, and the five remaining, BMNH 1967618/2–6, as paralectotypes.

**Additional material:** COSTA RICA: 2, LACM 38–39.4, Cocos Island, depth not stated (Allan Hancock Foundation); 3, USNM 210799, Cocos Island, 120 m; 1, USNM 122968, Cocos Island, 120 m; 1, ANSP A13339, Cocos Island, 80–88 m; 1, D.R. Shasky Collection, Redlands, California, Cocos Island, 137 m. PERU: 2, BMNH (de Burgh Collection, Accession No. 1822).

**Distribution:** *Placiphorella blainvillii* has been collected only off Peru and Cocos Island, Costa Rica. Smith & Ferreira (1977) included this species in their review of the chiton fauna of the Galapagos Islands, although no specimens of this species have ever actually been recorded from that locality. The verified northernmost record is Cocos Island, Costa Rica (05°34'N, 86°58'W); the southernmost record is the type locality.

**Habitat:** *Placiphorella blainvillii* has been taken on rocks and dead coral heads.

**Remarks:** *Placiphorella blainvillii* is morphologically similar to *P. mirabilis*, but may be distinguished by its smooth, cylindrical setae scales, and the shape of the rachidian radular tooth which is sharply truncated at the posterior third, where it forms three sharp denticles (see discussion under *P. mirabilis*).

*Placiphorella mirabilis* Clark, sp. nov.

(Figures 20–22, 34, 35)

*Placiphorella stimpsoni* (Gould), Dall, 1921:127 (in part); Burghardt & Burghardt, 1969:36; Putnam, 1980:12, 132 (in part). *Non Chiton stimpsoni* Gould, 1859.

**Diagnosis:** Small chitons (to 3.0 cm), oval in outline; valves pink, speckled with dark brown and white, and suffused with pale olive or brownish green. Girdle nearly nude, except at periphery and (rarely) in front of head; scales of peripheral setae with latticelike sculpture, bearing a sharp

spicule at distal end. Rachidian tooth of radula nearly trapezoidal in shape, widest at base.

**Description:** Body (Figure 20) broadly oval in outline, valves subcarinate, side slopes straight to convex, tegmentum microgranular, pink, speckled with dark brown and white, and suffused with green, occasionally with brown or green subjugal triangles; girdle broadly extended anteriorly, uniformly cream to light tan in color. Holotype (Figure 21), 15.25 mm  $\times$  10.1 mm  $\times$  3.0 mm. Largest specimen examined 29.0 mm  $\times$  23.0 mm  $\times$  5.0 mm (C.M. Hertz Collection, San Diego, California).

**Valves:** Head valve narrowly crescent-shaped, anterior slope straight to slightly convex, with small rounded notch at apex; tegmental surface smooth except for concentric growth lines; anterior margin barely raised; interior smooth, strongly thickened anteriorly; insertion teeth short, thick, and weakly pectinate, with (normally) eight slits, sometimes more due to splitting; slit rays inconspicuous.

Intermediate valves oblong in outline, very wide and short, widest at valve iv, subcarinate, beaked posteriorly, weakly false-beaked anteriorly; lateral areas slightly raised, with obsolete diagonal rib; central areas smooth except for concentric growth lines; interior smooth, with transverse callus extending from center to near slits; slit rays porous and barely perceptible in young, obsolete in adults; sutural laminae very large and thick, nearly straight, sharp at anterior edge, strongly squared at outer edge, especially in valves v–vii, widely incised by jugal sinus, usually slightly connected across jugum; insertion teeth long for genus, usually extending beyond narrow eaves, lateral surface of teeth slightly pectinate, insertion teeth and sutural laminae upswept at sides of slit.

Tail valve small, roughly rhombic, width (including articulation) less than half the width of valve iv; anterior margin convex, without false beak; mucro slightly raised, situated near posterior edge, with moderate caudal sinus; central anterior area smooth, convex; diagonal ribs raised and smooth, posterior area thickened, roughened by growth lines; interior of valve smooth, posteriorly calloused; sutural laminae broad, anterior edge sharp, lateral edge sharply squared, separated by narrow sinus; insertion teeth short but clearly defined, with one slit per side separated by wide sinus.

**Girdle:** Perinotum mostly nude, bearing three series of scaled bristles: primary series, five large bristles in front of anterior valve (nearly always missing), one each adjacent to valve sutures, at about midpoint of girdle, and three behind posterior valve; long, narrow submarginal series (Figure 34) (up to 3 mm long), with tightly packed scales; and short, thick, very spinose marginal series about 0.5 mm long; scales (Figure 35) measuring about 130  $\mu\text{m}$  in length, and 25  $\mu\text{m}$  in width, tapering distally, and bearing short, broad, pointed spicule at distal end and scattered, minute spicules about 20  $\mu\text{m}$  long, especially on anterior flap. Hyponotum densely covered with minute, outwardly directed spicules, about 10–20  $\mu\text{m}$  long, extending from

about suture of valves ii and iii to anal region; anterior flap almost entirely devoid of spicules, but bearing minute papillae, often coalescing in a vermicular pattern; margin of girdle fringed with narrow spicules (Figure 31) about 100  $\mu\text{m}$  in length.

Pallial fold well developed; modified anteriorly into 12–14 tentacles (Figure 62), largest at center, becoming smaller toward edges, bearing minute, triangular, pointed scales about 20–30  $\mu\text{m}$  long. Gills holobranchial, about 15–18 per side, extending from valve ii to valve vii.

*Radula* (Figure 22): (paratype LACM 2704, 18 mm in length) 4 mm long, with about 37 rows of mature teeth; rachidian tooth nearly trapezoidal, broadly dilated proximally to nearly twice the width of the working edge; spatulate uncinals about 200  $\mu\text{m}$  in length, broadly rounded distally, to about twice width of proximal end.

**Type locality:** 1.9 km, 130° T from Long Point, S end of Santa Catalina Island, California (33°23.5'N, 115°13.3'W), 69 m.

**Type material:** Holotype, LACM 2703 (leg. R. Reimer, B. Banta, G. Bakus, R/V *Velero IV*; 13 February 1965) (Allan Hancock Foundation); 7 paratypes: CALIFORNIA: 1, LACM 2704, E of Long Point, Santa Catalina Island, 82–91 m (leg. R/V *Velero III*, 10 August 1941); 1, LACM 2705, E of White Cove, Santa Catalina Island, 66 m (leg. R/V *Velero IV*, 31 October 1948); 2, LACM 2706, 110° T from Ship Rock, Santa Catalina Island, 82 m (leg. R. Reimer, et al., R/V *Velero IV*; 13 February 1965); 3, RNC 559, SW of Catalina Island, 30–40 m (leg. E. Edmonds, June 1948).

One additional, non-topotypic paratype: RNC 1079, W side of San Nicolas Island, California, 33–35 m (leg. RNC, 15 October 1991).

**Additional material:** CALIFORNIA: 1, RNC 653, Gaviota, Santa Barbara County; 1, SBMNH 19157, Santa Cruz Island, 78–80 m; 3, CAS 017862, Santa Cruz Island, depth not stated; 1, CAS 01640, Redondo Beach, 46 m; 2, RNC 128, Pyramid Cove, San Clemente Island, 37–41 m on rock; 4, C.M. Hertz Collection nine Mile Bank, off San Diego County, 137 m; 1, LACM 48-43.7, SE of Santa Cruz Island, 42 m; 3, LACM 50-20.3, S of W end of Anacapa Island, 51 m. MEXICO: 2, LACM 71-150.6, SE of Cabo San Quintín, Baja California Norte, 40–55 m; 1, LACM 39-115.1, rock, N end of Ranger Bank (near Isla Cedros), 146–155 m, Baja California Norte; 1, CAS 017465, Cedros Island, Baja California Norte; 1, SBMNH 35630, 22 km off Cabo Colnett, Baja California Norte; depth not stated, 1, SBMNH 35632, tail valve only, Bahía San Bartolomé (Turtle Bay), Baja California Sur; 1, SBMNH 35633, tail valve only, Isla Asunción, Baja California Sur, depth not stated.

**Distribution:** *Placiphorella mirabilis* has a continuous distribution between Gaviota, Santa Barbara County, Cali-

fornia (34°28'N, 120°14'W) (RNC 653), and Isla Asunción, Baja California Sur, Mexico (27°06'N, 114°18'N).

**Habitat:** *Placiphorella mirabilis* is found from 28–155 m on large cobbles, boulders, and rock cliffs.

**Remarks:** At first glance, *Placiphorella mirabilis* appears to be a stunted offshore form of *P. velata* because of the similar coloration of the valves. However, close examination of the placement and structure of the setae reveals it to be a distinct species. *Placiphorella mirabilis* is morphologically similar to *P. atlantica*, *P. blainvillii*, and *P. ruja*, but may be distinguished from these species by the following: (1) setae restricted to periphery of girdle, except for four to five very large setae in front of head valve; (2) peripheral setae very fine and spinose; (3) spicules of setae with latticelike sculpture; (4) trapezoidal shape of rachidian tooth of radula, which is nearly twice as wide at the base as at the working end.

**Etymology:** The name in Latin means wonderful, suggested by the beautiful coloration of the tegmentum.

*Placiphorella hanselmani* Clark, sp. nov.

(Figures 23–25, 36, 37)

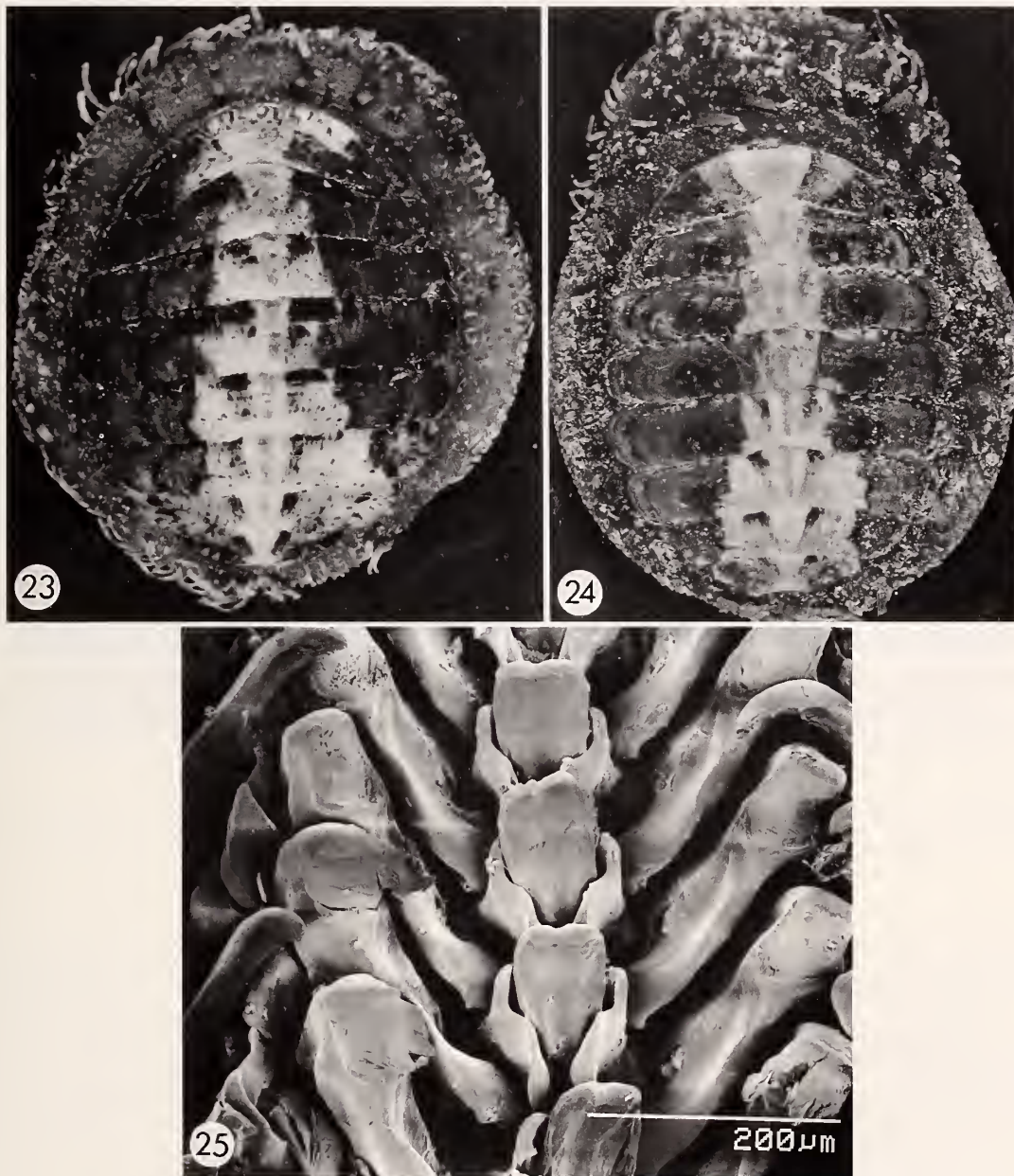
*Placiphorella velata* Carpenter MS, Dall, Thorpe (in Keen), 1971:882; Skoglund, 1989:86.

**Diagnosis:** Chitons of medium size (to 3.6 cm), broadly oval in outline; valves buff, speckled with dark brown in the center one-fourth to one-third, remaining portion of valves dark brown. Scales of setae broadly cylindrical, tapering to point proximally, truncated distally, bearing spicule at distal end. Rachidian tooth of radula heart-shaped.

**Description:** Body (Figure 23) broadly oval in outline; valves depressed, subcarinate, side slopes straight, tegmentum microgranular, color buff, speckled with dark brown on jugal areas and central portion of anterior valve, speckling usually extending to upper fourth or more of pleural areas (especially on valves v–vii), jugal areas bordered with dark brown triangles, remaining portions of valves dark brown. Girdle broadly extended anteriorly, covered with rather short, stiff setae, uniform light brown in color. Holotype (Figure 24) 25.5 mm  $\times$  19.5 mm  $\times$  4.2 mm. Largest specimen examined RNC (512) 36.0 mm  $\times$  29.0 mm  $\times$  9.0 mm.

**Valves:** Head valve crescent-shaped, anterior slope straight to slightly concave, becoming thickened and somewhat convex in older specimens; posterior margin slightly raised; apical notch small, round; tegmentum sculptureless except for concentric growth lines; interior smooth, thickened anteriorly; insertion teeth short, not extending beyond tegmentum, thick and strongly pectinate (as defined in Saito & Okutani, 1989), with (normally) eight slits; slit rays faint in juveniles, obsolete in adults.

Intermediate valves oblong in outline, very wide and



Explanation of Figures 23 to 25

*Placiphorella hanselmani* Clark, sp. nov.

Figure 23. Whole animal, Paratype, Hanselman collection, Isla Pata, Bahía de Los Ángeles, Gulf of California, Baja California, Mexico. 22.0 mm × 20.0 mm.

short, widest at valve iv, subcarinate, beaked posteriorly, slightly false-beaked anteriorly; lateral areas raised, flattened, and cut by a shallow sulcus into two low (often obsolete) ribs; central areas nearly smooth except for growth lines; interior smooth, with transverse callus running from center to near slits; slit rays faint and porous in juveniles,

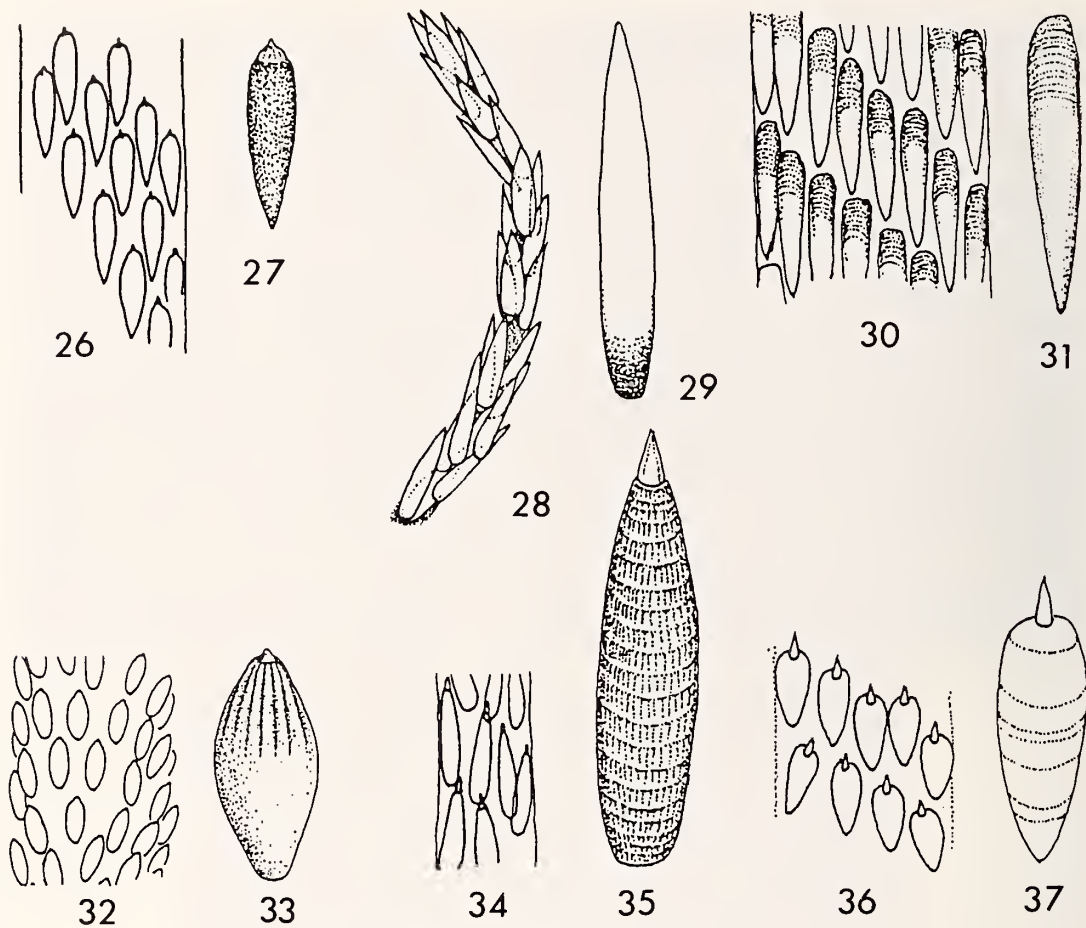
Figure 24. Holotype, LACM 2707. Bahía de Los Ángeles, Gulf of California, Baja California, intertidal.

Figure 25. Radula, Paratype, CAS 075732. Puerto Don Juan, S end of Bahía de Los Ángeles, 5 m.

obsolete in adults; sutural laminae very large and thick, nearly straight, sharp at anterior edge, separated by wide jugal sinus, usually connected across jugum; insertion teeth short, not extending beyond eaves, pectinate and upswept at sides of slits, of which there is one (rarely two) per side.

Tail valve small, roughly rhombic, width including ar-





## Explanation of Figures 26 to 37

Setae and setae scales/spicules.

Figures 26, 27. *Placiphorella velata* Dall, 1879, ex Carpenter MS. Figure 26, Seta; bar = 0.5 mm. Figure 27, Scale of seta; bar = 0.2 mm.

Figures 28, 29. *Placiphorella atlantica* (Verrill & Smith, 1882). Figure 28, Seta; bar = 1.0 mm. (after Theile, 1910). Figure 29, Spicule of seta; bar = 10  $\mu$ m.

Figures 30, 31. *Placiphorella rufa* Berry, 1917. Figure 30, Seta; bar = 0.5 mm. Figure 31, Scale of seta; bar = 250  $\mu$ m.

Figures 32, 33. *Placiphorella borealis* Pilsbry, 1892 (after Saito & Okutani, 1989). Figure 32, Seta; bar = 0.5 mm. Figure 33, Scale of seta; bar = 200  $\mu$ m.

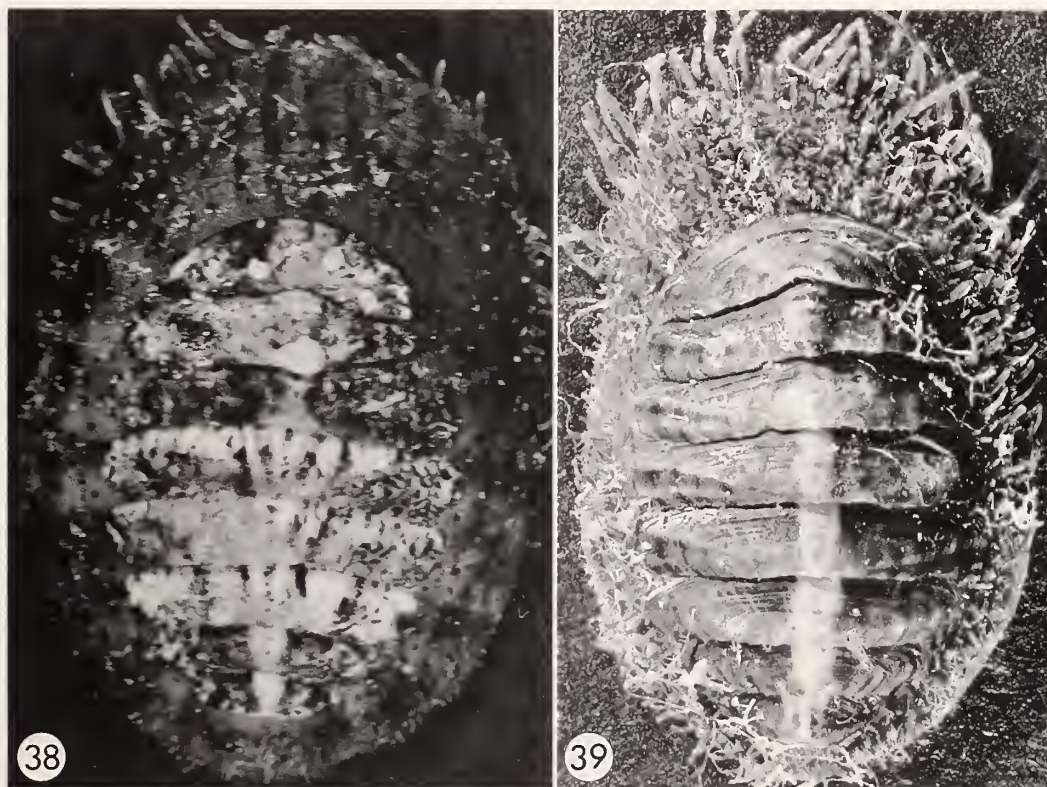
Figures 34, 35. *Placiphorella mirabilis* Clark, sp. nov. Figure 34, Seta; bar = 0.5 mm. Figure 35, Spicule of seta; bar = 100  $\mu$ m.

Figures 36, 37. *Placiphorella hanselmani* Clark, sp. nov. Figure 36, Seta; bar = 0.5 mm. Figure 37, Scale of seta; bar = 250  $\mu$ m.

ticulamentum about half width of valve v tegmentum; anterior margin sharply convex, without false beak; mucro posterior and slightly raised, with shallow sinus; anterior area smooth except for growth lines, convex anterior of mucro; lateral ribs raised and smooth, posterior area depressed; sutural laminae broad, truncated anteriorly, separated by jugal sinus; insertion teeth very short; with one slit per side.

*Girdle*: Perinotum covered with scaled bristles (Figure 36) in several series and sizes, largest at about midpoint of girdle, of which there is one adjacent to each suture,

and five around anterior valve, a smaller series in the sutures, and a similar series near the outer margin, other bristles of various sizes randomly scattered; bristle scales (Figure 37) elongated, tapered, truncated distally, with sharp spicule at distal end, about 250  $\mu$ m long and 75  $\mu$ m wide. Hyponotum densely covered with minute, narrow, smooth, outwardly directed, pointed scales about 10–20  $\mu$ m long from suture of valve i and ii to anal region, largest near pallial fold, becoming smaller toward outer margin, like velvet in appearance under moderate magnification; anterior flap with very sparsely placed, minute scales, about



Explanation of Figures 38 and 39

38. *Placiphorella stimpsoni* (Gould, 1859). Whole animal, RNC 387. Katakai, Shimane Peninsula, Honshu, Japan, 0.5–2 m. 38.0 mm × 26.0 mm.

Figure 39. *Placiphorella borealijaponica* Saito & Okutani, 1989. Whole animal, RNC 124. Vostok Bay, Sea of Japan, Russia, 15 m. 23.5 mm × 15.0 mm.

20  $\mu$ m long, similar to those on rest of hyponotum, also uniformly covered with tiny papillae, usually coalescing in a vermicular pattern; margin of girdle fringed with narrow, sharp, longitudinally striated spicules about 50  $\mu$ m long.

Pallial fold well developed, incised posteriorly, modified anteriorly into numerous precephalic tentacles, about 20 in adults, largest in center, becoming gradually smaller toward edges. Gills holobranchial, extending from valve ii to valve vii.

*Radula*: (Figure 25) (paratype, CAS 075732) 5 mm long, with about 52 rows of mature teeth; rachidian tooth elongated-heart-shaped, broadened proximally; spatulate uncinals about uniform in width along entire length, outside edge rounded at distal end, inside edge straight.

**Type locality**: Bahía de Los Ángeles, Baja California Norte (Gulf of California), Mexico (28°57'N, 113°32'W), 0–5 m on bottoms of cobbles.

**Type material**: Holotype, LACM 2707 (leg. Carl & Laura Shy; intertidal; May, 1976); paratypes: 1, LACM 2708 (same data as holotype); 1, SBMNH 35628 (leg. F. B.

Howard; intertidal; May 1960); 1, CAS 075732, Puerto Don Juan, S end of Bahía de Los Ángeles, 5 m (leg. Antonio J. Ferreira; SCUBA; 5 October 1984); 2, G.A. Hanselman collection, San Diego, California, Turtle Pin Cove, Isla Smith, Bahía de Los Ángeles, 1 m (leg. G.A. Hanselman; 12 May 1976); 1, G.A. Hanselman collection; Isla Pata, Bahía de Los Ángeles, 0.5–1 m (leg. G.A. Hanselman; 12 May 1976).

Two additional, non-topotypic paratypes: 2, RNC 386 and 512, Puerto de Lobos, Sonora, Mexico, intertidal (leg. Thomas C. Rice; 25 April 1979).

**Additional material**: MEXICO: G.A. Hanselman collection; Bahía de Los Ángeles, dredged, 21–39 m (leg. Paul and Carol Skoglund; May 1976); 1, CAS 017719, Cholla Bay, Sonora (collector and date unknown). Carol Skoglund (personal communication, September 1992) reports “a few” specimens from Puerto de Lobos and Puerto de la Libertad, Sonora, Mexico (color slide of juvenile, 11.0 mm in length from the latter locality: CAS color slide collection, AJF 491/6).

**Distribution**: Restricted to the upper Gulf of California,

north of 28°N latitude, where it has been collected at several localities in Bahía de Los Ángeles (the type locality) on the Baja California peninsula side, and Puerto de Lobos and Puerto de la Libertad on the mainland side.

**Habitat:** *Placiphorella hanselmani* is found on bottoms of medium-sized to large cobbles and boulders lightly bedded in the substrate, from the low intertidal to about 39 m.

**Remarks:** *Placiphorella hanselmani* is morphologically similar to both *P. velata*, with which it has been confused, and *P. blainvillii*, but may be distinguished from both of these species by: (1) scales of setae, which are about 2.5 times as long as wide, distally truncated, and bear a long, sharply pointed spicule at the distal end; (2) the heart-shaped rachidian tooth of the radula, which is very broad at the working end; (3) the consistent color pattern.

**Etymology:** Named after George A. Hanselman, of San Diego, California, who has guided and inspired much of my work.

## DISCUSSION

Two additional species of *Placiphorella* occur in the shallow waters of northeast Asia, *Placiphorella stimpsoni* (Gould, 1859) and *Placiphorella borealijaponica* Saito & Okutani, 1989. These two species (along with *P. borealis* Pilsbry, 1893) were recently treated by Saito & Okutani (1989).

*Placiphorella stimpsoni* (Figure 38) is morphologically similar to *P. velata*, *P. blainvillii*, and *P. hanselmani*, but may be easily distinguished from all of them by: (1) setae scales, which in *P. stimpsoni* are very long (up to 350  $\mu\text{m}$ ), weakly striated distally, and bear a short spicule at the tip; (2) color of valves whitish, irregularly streaked and mottled with pink, brown, black, and blue-green.

*Placiphorella stimpsoni* is distributed in Japan from southern Hokkaido (Sea of Japan), along the Pacific coast to Kyushu (East China Sea) in the littoral and shallow sublittoral zones (Saito & Okutani, 1989). It has also been reported in western Korea from Karorim Bay to Hataedo (Yellow Sea) in the shallow subtidal (Dell'Angelo et al., 1990). Reports of *P. stimpsoni* from Russian waters are misidentifications *P. borealijaponica*. Reports of *P. stimpsoni* from North American waters (Dall, 1921; Oldroyd, 1927; Bernard, 1967; Burghardt & Burghardt, 1969; Abbott, 1974; Putman, 1980) are misidentifications of *P. velata* and *P. mirabilis*. *Placiphorella japonica* (Dall, 1925) is a synonym.

Material examined: JAPAN: 2, RNC 387, Katak, Snimane Peninsula, Honshu, 1, CAS 031637, Sagami Bay, Honshu, 1, CAS 078506, Hiroshima Prefecture, Honshu, 1, CAS 080694, Sagami Bay, Honshu; 1, CAS 082595, Wakayama Prefecture, Honshu. KOREA: 1, CAS 014407, Chinhay; 1, RNC 1500, Karorim Bay.

Fossil valves of *Placiphorella stimpsoni* have been found in the Pleistocene deposits of the Boso Peninsula (near Tokyo), Honshu, Japan (Itoigawa et al., 1976).

*Placiphorella borealijaponica* (Figure 39) is morphologically similar to *P. borealis*, but may be distinguished by: (1) lack of radial ribs (or sulci) on the head valve; (2) scales of the setae in which the distal half forms three low, distally converging lobes, truncated at the distal end and bearing a short, broad spicule (the setae scales of *P. borealis* bear numerous striations along the distal half and a short, broad spicule at the end); (3) valves sometimes bearing whitish or pale blue-green streaks on the latero-pleural areas; (4) interior of valves tinted blue-green.

*Placiphorella borealijaponica* is distributed in Japan from northern Hokkaido (Okhotsk Sea), to the north end of Honshu (Saito & Okutani, 1989) and along the Japan Sea coast of Russia, and the southeast (Tartar Strait) coast of Sakhalin Island. Reports of *P. stimpsoni* in Russian waters (Yakovleva, 1952; Sirenko, 1976; Sirenko, 1985) are referable to this species.

Material examined: RUSSIA (JAPAN SEA): 7, LACM 91-91.1, Vostok Bay; 2, RNC 96, Vostok Bay; 2 RNC 124, Vostok Bay; 3, CAS 014408, Vostok Bay; 1, CAS 078434, Sudzuche Bay. JAPAN: 1, RNC 732, Hokkaido; 1, CAS 066637, Oshoro, Hokkaido; 1, CAS 066406, Oshoro, Hokkaido.

Fossil valves of *P. borealijaponica* have been reported from Pleistocene deposits of the Boso Peninsula, Honshu (as *P. japonica*) (Itoigawa et al., 1976).

### Key to the genus *Placiphorella* Dall, 1879, ex Carpenter MS

- 1a Valves dark brown (may be streaked with light brown, white or pale blue-green) with whitish jugal stripe ..... 2
- 1b Color of valves not as above ..... 3
- 2a Head valve with numerous low, radiating ribs; valves unstreaked; interior of valves white ....  
..... *P. borealis* Pilsbry, 1892
- 2b Head valve without low radiating ribs; valves often streaked; interior of valves light blue-green (Japan, Russia) .....  
..... *P. borealijaponica* Saito & Okutani, 1989
- 3a Valves uniform in color ..... 4
- 3b Valves not uniform in color ..... 5
- 4a Valves reddish (head valve may be paler) .....  
..... *P. rufa* Berry, 1917
- 4b Valves white (Cosmopolitan) .....  
..... *P. atlantica* (Verrill & Smith, 1882)
- 5a Setae restricted to periphery of girdle and around head valve (the latter often absent); scales of setae tapering to a point distally and bearing latticelike sculpturing (California, Baja California) ....  
..... *P. mirabilis* Clark, sp. nov.
- 5b Setae and scales of setae not as above ..... 6
- 6a Scales of setae 200–260  $\mu\text{m}$  in length, smooth, cylindrical, and distally pointed (Central and South America) ..... *P. blainvillii* (Broderip, 1832)

- 6b Scales of setae not as above ..... 7  
 7a Scales of setae very large (up to 350  $\mu\text{m}$  in length);  
 distal end weakly striated and bearing a short  
 spicule (Japan, Korea) .....  
 ..... *P. simpsoni* (Gould, 1859)  
 7b Scales of setae smaller and not distally striated .. 8  
 8a Scales of setae 190–200  $\mu\text{m}$  in length, 40–45  $\mu\text{m}$   
 in width; distal end rounded and bearing a short  
 spicule .... *P. velata* Dall, 1879, ex Carpenter MS  
 8b Scales of setae 250  $\mu\text{m}$  in length, 75  $\mu\text{m}$  in width;  
 truncated distally and bearing a large spicule  
 (Gulf of California) .....  
 ..... *P. hanselmani* Clark, sp. nov.

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